GRASSLAND BYPASS PROJECT

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Project Impacts on the San Joaquin River

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Introduction

The purpose of this chapter is to compare the loads of salt discharged by the Grassland Bypass Project (GBP) with loads that might exist in the absence of the Project. This comparison uses flow and salinity data for Stations B, D, F, and N from October 1985 to September 2001. Two methods are used:

1. simple comparison of flow and salt loads as percentages, and
2. a theoretical dilution analysis.

The theoretical dilution analysis was agreed upon in meetings involving the US Bureau of Reclamation, the South Delta Water Agency and its legal counsel, and the California Regional Water Quality Control Board, as a means of demonstrating that the Project was not causing adverse downstream impacts. This analysis was not specified in the Compliance Monitoring Program (USBR, 1996) or the Quality Assurance Project Plan (Entrix, 1997). Work continues to standardize the methodologies used to calculate loads and the theoretical dilution.

The 1995 Agreement for Use of the San Luis Drain includes the following statement:

> "It is the objective and intention of RECLAMATION and the AUTHORITY, among other things, to ensure that the use of the Drain as provided in this Agreement does not result in degradation of water quality in the San Joaquin River relative to the quality that would exist in the absence of the project and does not reduce the ability to meet the salinity standard at Vernalis compared to the ability to meet the salinity standard that would exist in the absence of the project." (USBR, et. al., 1995)

Comparison of Flow and Salt Loads as Percentages

Table 1 compares the monthly flows and loads of salt discharged by the GBP with those in the San Joaquin River at Crows Landing. During WY 2001, discharge from the GBP was 4 percent of the flow and about 19 percent of the salt load in the river as measured at Crows Landing.

Tables 2a, 2b, and 2c compare the volumes of water discharged from the 97,000 acre Grassland Drainage Area (GDA) with flow in the Mud and Salt Slough watershed. During the WY 2001, 28,300 acre-feet of water were discharged from the GDA, which was approximately 12 percent of the 226,800 acre-feet that flowed from the region. The WY 2001 volume was about 39 percent less than the average annual volume of drainage water discharged prior to the GBP (28,300 acre-feet vs. 49,800 acre-feet).

Tables 3a, 3b, and 3c compare the loads of salts discharged from the GDA with the salts in Mud and Salt Sloughs. During the WY 2001, about 120,000 tons of salt were discharged from the GDA, which was almost 31 percent of the 383,200 tons left the region in Mud and Salt Sloughs. The WY 2001 salt load was about 37 percent less than the average annual salt load discharged prior to the GBP (120,000 tons vs. 190,500 tons) between WY 1986 and WY 1996. The WY 2001 regional salt load was about the same as the average annual salt load discharged prior to the GBP (383,200 tons versus 388,300 tons).

Theoretical Dilution of GBP Discharges to Meet Vernalis Standards

In order to assess the effect of GBP on salinity in the San Joaquin River, an analysis was developed to theoretically isolate the effects of GBP from other activities potentially affecting salinity concentrations in the river. Drainage from GBP was assumed as the only drainage relevant to project related changes in salt load on the San Joaquin River. The analysis was cast in terms of theoretical dilution water needed to bring the GBP discharges to the Vernalis seasonal EC objectives.

The salinity objectives for Vernalis are 1,000 µS/cm (640 mg/L) in the winter months (September–March) and 700 µS/cm (448 mg/L) in the summer months (April–August)(CVRWQCB 1998).

This analysis does not take into account any of the other operational criteria, nor does it consider salinity contributions to the River other than those derived from the GDA. The value of the analysis is that it permits a "with" and "without" project comparison with prior year hydrology, in terms (water quality releases from a reservoir) meaningful to water users and managers.

The assimilative capacity analysis considers the total volume of dilution water (assumed to have a salinity of 156 µS/cm (100 mg/L)) that would be needed to reduce the drainage water alone to the salinity objective.

Table 1. Comparison of Flows and Salt Loads Discharged by the Grassland Bypass Project to the San Joaquin River (WY 1997 - 2001)

	Flow			Salt Load		
	Discharged from GDA	San Joaquin River at Crows Landing		Discharged from GDA	San Joaquin River at Crows Landing	
	Station B	Station N	B as %	Station B	Station N	B as %
	acre-feet	acre-feet	of N	tons	tons	of N
Monthly Totals						
Oct-1996	1,276	62,290	2%	5,070	33,262	15%
Nov-1996	1,569	61,120	3%	6,048	44,792	14%
Dec-1996	1,946	268,300	1%	8,020	73,753	11%
Jan-1997	3,703	1,574,000	0%	15,433	220,954	7%
Feb-1997	4,173	1,299,000	0%	20,463	253,517	8%
Mar-1997	4,876	283,700	2%	22,913	178,110	13%
Apr-1997	4,453	80,480	6%	24,111	73,128	33%
May-1997	4,215	76,100	6%	20,063	58,784	34%
Jun-1997	3,457	35,980	10%	16,153	42,186	38%
Jul-1997	3,277	35,850	9%	13,873	35,876	39%
Aug-1997	3,159	37,630	8%	11,117	41,729	27%
Sep-1997	1,445	29,820	5%	4,474	24,611	18%
Oct-1997	1,756	39,860	4%	7,819	34,861	22%
Nov-1997	1,558	44,690	3%	6,594	49,011	13%
Dec-1997	1,406	53,260	3%	6,221	60,705	10%
Jan-1998	1,421	139,600	1%	7,036	80,603	9%
Feb-1998	6,993	1,001,000	1%	23,906	360,319	7%
Mar-1998	7,106	623,100	1%	34,244	266,927	13%
Apr-1998	5,527	832,100	1%	29,250	238,007	12%
May-1998	4,890	743,600	1%	27,036	152,762	18%
Jun-1998	3,635	707,300	1%	16,740	109,320	15%
Jul-1998	4,572	502,700	1%	18,494	69,341	27%
Aug-1998	3,883	108,100	4%	15,561	47,242	33%
Sep-1998	3,193	109,600	3%	12,203	42,371	29%
Oct-1998	2,040	128,600	2%	9,742	44,509	22%
Nov-1998	1,530	73,090	2%	7,546	52,300	14%
Dec-1998	1,450	95,490	2%	7,142	52,295	14%
Jan-1999	1,700	96,020	2%	7,909	64,734	12%
Feb-1999	3,310	161,500	2%	14,883	82,991	18%
Mar-1999	3,450	113,600	3%	17,743	101,750	17%
Apr-1999	2,080	115,200	2%	11,532	72,955	16%
May-1999	2,960	84,070	4%	13,830	54,820	25%
Jun-1999	3,610	40,690	9%	16,252	44,925	36%
Jul-1999	3,870	34,840	11%	17,068	37,983	45%
Aug-1999	3,910	37,810	10%	15,596	39,320	40%
Sep-1999	2,400	34,440	7%	9,890	31,517	31%
Oct-1999	1,850	51,890	4%	8,329	38,233	22%
Nov-1999	1,710	52,230	3%	7,334	48,036	15%
Dec-1999	1,400	42,230	3%	6,177	47,265	13%
Jan-2000	1,720	59,110	3%	7,520	58,618	13%
Feb-2000	3,190	201,700	2%	14,844	90,098	16%
Mar-2000	3,330	274,900	1%	16,916	136,826	12%
Apr-2000	2,660	100,200	3%	13,039	70,370	19%
May-2000	2,850	84,830	3%	12,157	65,234	19%
Jun-2000	3,630	43,800	8%	15,313	44,821	34%
Jul-2000	3,660	41,610	9%	14,344	40,284	36%
Aug-2000	3,470	38,800	9%	12,180	35,341	34%
Sep-2000	1,790	36,180	5%	6,843	28,751	24%
Oct-2000	1,265	64,622	2%	4,991	34,895	14%
Nov-2000	1,180	62,365	2%	4,690	38,171	12%
Dec-2000	1,458	51,105	3%	5,734	46,135	12%
Jan-2001	1,718	59,338	3%	6,946	61,974	11%
Feb-2001	3,108	60,475	5%	13,279	71,153	19%
Mar-2001	3,491	97,685	4%	17,748	108,025	16%
Apr-2001	2,130	71,848	3%	10,926	63,653	17%
May-2001	2,454	71,229	3%	11,083	70,764	16%
Jun-2001	3,128	31,028	10%	13,461	36,138	37%
Jul-2001	3,560	28,999	12%	13,833	32,218	43%
Aug-2001	3,435	28,999	12%	12,074	32,284	37%
Sep-2001	1,307	22,251	6%	5,246	25,028	21%
Annual Totals						
WY 1997	37,550	3,844,270	1%	167,739	1,080,703	16%
WY 1998	45,939	4,904,910	1%	205,104	1,511,470	14%
WY 1999	32,310	1,015,350	3%	149,133	680,098	22%
WY 2000	31,260	1,027,480	3%	134,994	703,876	19%
WY 2001	28,234	649,944	4%	120,011	620,438	19%

Table 2a. Annual Volume of Water Discharged from the Grassland Drainage Area and Mud/Salt Slough Watershed

Water Year (1)		% CVP Contract Delivery (2)	Discharge from GDA (3)	Discharge from Region (4)	GDA discharge as percent of Regional discharge
			acre-feet	acre-feet	
WY 1986		100%	67,006	284,316	24%
WY 1987		100%	74,902	233,843	32%
WY 1988		100%	65,327	230,454	28%
WY 1989		100%	54,186	211,393	26%
WY 1990		50%	41,662	194,656	21%
WY 1991		25%	29,290	102,162	29%
WY 1992		25%	24,533	85,428	29%
WY 1993		50%	41,197	167,955	25%
WY 1994		35%	38,670	183,546	21%
WY 1995		100%	57,574	263,769	22%
WY 1996		95%	52,978	267,948	20%
WY 1997	GBP	90%	37,550	287,210	13%
WY 1998	GBP	100%	45,939	378,680	12%
WY 1999	GBP	70%	32,310	253,130	13%
WY 2000	GBP	65%	31,260	235,490	13%
WY 2001	GBP	49%	28,254	226,763	12%

Table 2b. Comparison of WY 2001 Discharge Volume to Previous Years

	Water Year	Discharge from GDA (3)	WY 2001 difference	Discharge from Region (4)	WY 2001 difference
		acre-feet		acre-feet	
Average, all years	1986 - 2001	45,165	-37%	225,421	1%
Prior years average	1986 - 2000	46,292	-39%	225,332	1%
Before GBP average	1986 - 1996	49,757	-43%	202,315	12%
GBP average	1997 - 2001	35,063	-19%	276,255	-18%
Drought years	(5)	33,934	-17%	160,085	42%
Wet years	(6)	54,145	-48%	260,520	-13%

Table 2c. Total Volumes of Water

	Water Years	Discharge from GDA (3)	Discharge from Region (4)	GDA discharge as percent of Regional discharge
		acre-feet	acre-feet	
All years	1986 - 2001	722,638	3,606,743	20%
Before GBP	1986 - 1996	547,325	2,225,470	25%
GBP total	1997 - 2001	175,313	1,381,273	13%

Notes:

Data compiled by Nigel Quinn, LBNL, from CVRWQCB and USGS reports.

(1) Water Year - October 1 - September 30

(2) Percent of Contract Delivery of CVP water to Delta Division and San Luis Unit

(3) Grassland Drainage Area

(4) Mud and Salt Sloughs

(5) Drought Years with 50% or less CVP delivery: WY 1990 - 1994, 2001

(6) Wet Years with more than 50 percent CVP delivery: WY 1986 - 1989, 1995 - 2000

Table 3a. Annual Loads of Salt Discharged from the Grassland Drainage Area and Mud/Salt Slough Watershed

Water Year (1)		% CVP Contract Delivery (2)	Discharge from GDA (3)	Discharge from Region (4)	GDA load as percent of Regional load
			tons	tons	
WY 1986		100%	214,250	494,544	43%
WY 1987		100%	241,526	438,904	55%
WY 1988		100%	236,301	455,956	52%
WY 1989		100%	202,420	389,325	52%
WY 1990		50%	171,265	380,564	45%
WY 1991		25%	129,899	221,542	59%
WY 1992		25%	110,327	197,352	56%
WY 1993		50%	183,021	336,522	54%
WY 1994		35%	171,495	379,408	45%
WY 1995		100%	237,530	499,339	48%
WY 1996		95%	197,526	477,725	41%
WY 1997	GBP	90%	167,739	446,690	38%
WY 1998	GBP	100%	205,104	627,687	33%
WY 1999	GBP	70%	149,133	401,616	37%
WY 2000	GBP	65%	134,994	372,453	36%
WY 2001	GBP	49%	120,008	383,155	31%

Table 3b. Comparison of WY 2001 Salt Loads to Previous Years

		Discharge from GDA (3)	WY 2001 difference	Discharge from Region (4)	WY 2001 difference
		acre-feet		acre-feet	
Average, all years	1986 - 2001	179,534	-33%	406,424	-6%
Prior years average	1986 - 2000	183,502	-35%	407,975	-6%
Before GBP average	1986 - 1996	190,505	-37%	388,289	-1%
GBP average	1997 - 2001	155,396	-23%	446,320	-14%
Drought years (2)	(5)	147,669	-19%	316,424	21%
Wet years	(6)	202,814	-41%	457,800	-16%

Table 3c. Total Salts

		Discharge from GDA (3)	Discharge from Region (4)	GDA load as percent of Regional load
		tons	tons	
All years	1986 - 2001	2,872,538	6,502,782	44%
Before GBP	1986 - 1996	2,095,560	4,271,181	49%
GBP total	1997 - 2001	776,978	2,231,601	35%

Notes:

Data compiled by Nigel Quinn, LBNL, from CVRWQCB and USGS reports.

(1) Water Year - October 1 - September 30

(2) Percent of Contract Delivery of CVP water to Delta Division and San Luis Unit

(3) Grassland Drainage Area

(4) Mud and Salt Sloughs

(5) Drought Years with 50% or less CVP delivery: WY 1990 - 1994, 2001

(6) Wet Years with more than 50 percent CVP delivery: WY 1986 - 1989, 1995 - 2000

Note that the monthly volume of dilution water is highly dependent on the 156 μS/cm (100 mg/L) assumption. Note also that the relation between dilution water quality and required volume is non linear.

Figure 1 shows the theoretical volume of water that would be needed to dilute the combined salt loads from the GDA, measured at Station B, and the regional watershed, drained by Mud Slough and Salt Slough (Stations D & F), to meet the Vernalis standards. Figure 2 shows the total theoretical dilution requirement for each water year. The unshaded areas in Figures 1 and 2 represent the theoretical dilution requirements for salt loads generated by the Mud and Salt Slough watershed which includes the GDA and other agricultural areas, wetlands, and uncontrolled runoff from the Coast Range watersheds. The shaded area in the Figures shows the theoretical dilution requirements for salt loads discharged from only the GDA.

The data for Figure 2 are summarized in Tables 4a and 4b. During the WY 2001, about 174,500 acre-feet of water would have been needed to dilute the 28,300 acre-feet of drainage water discharged from the GDA. In comparison, approximately 458,800 acre-feet of water would have been needed to dilute the regional discharges of 226,800 acre-feet to meet the Vernalis standards. The WY 2001 theoretical dilution requirement for the GDA is about 36 percent less than that required during the years prior to the implementation of the GBP. The WY 2001 theoretical dilution requirement for the region was 28 percent higher than that required during the years prior to implementation of the GBP.

These percentages should be put into context of the 1990 – 1994 drought and the initiation of CVPIA deliveries to wetlands (private, State and Federal) in the Grasslands Basin that preceded the authorization of the Grassland Bypass Project. The latter has profoundly affected the hydrology of the Grasslands Basin and has affected the timing of salt loading to the San Joaquin River.

Drought occurred during WY 1990 to 1994 and WY 2001 when 50 percent or less of the contracted supplies of water were delivered to federal contractors in the San Luis Unit and Delta Division of the CVP. The volume of water discharged from the GBP in WY 2001 was comparable to that discharged during the 1990–1994 drought.

Data for the GDA for WY 1986 to 2001 show that between WY 1999 and WY 2001, the salt loads (Tables 3a and 3b) and theoretical dilution requirements (Tables 4a and 4b, and Figures 1 and 2) were smaller than in all other years with the exception of the drought years of WY 1991 and 1992.

The theoretical dilution required for the entire region in WY 2001 was 28 percent larger than the average of all prior years and greater than the average of above normal and wet years with CVP deliveries above 50 percent (Table 4b).

WY 1999, 2000, and 2001 had no unusual or unexpected hydrologic events as occurred in WY 1997 and WY 1998.

Data for several more years will be necessary before the impact of the GBP can be quantified with confidence.

Calculations

The formula for theoretical dilution is:

$Q_2 = Q_1(C_3 - C_1)/(C_2 - C_3)$

Q_1 = Drainwater discharge in acre-feet per month

Q_2 = Volume of water needed to dilute Q_1 to meet Vernalis standards in acre-feet per month

C_1 = Measured concentration of GBP drainage water in parts per million (mg/L)

C_2 = Assumed concentration of dilution water = 100 mg/L

C_3 = Vernalis standard concentration = 448 mg/L April - August 640 mg/L September - March

References

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U.S. Bureau of Reclamation, et. al. September 1996. Compliance Monitoring Program for Use and Operation of the Grassland Bypass Project, September 1996. U.S. Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

Figure 1. Monthly Volumes of Water Needed to Dilute Drainage Water from the Grassland Drainage Area and Regional Watershed to Meet Vernalis Standards (WY 1986 - 2001)

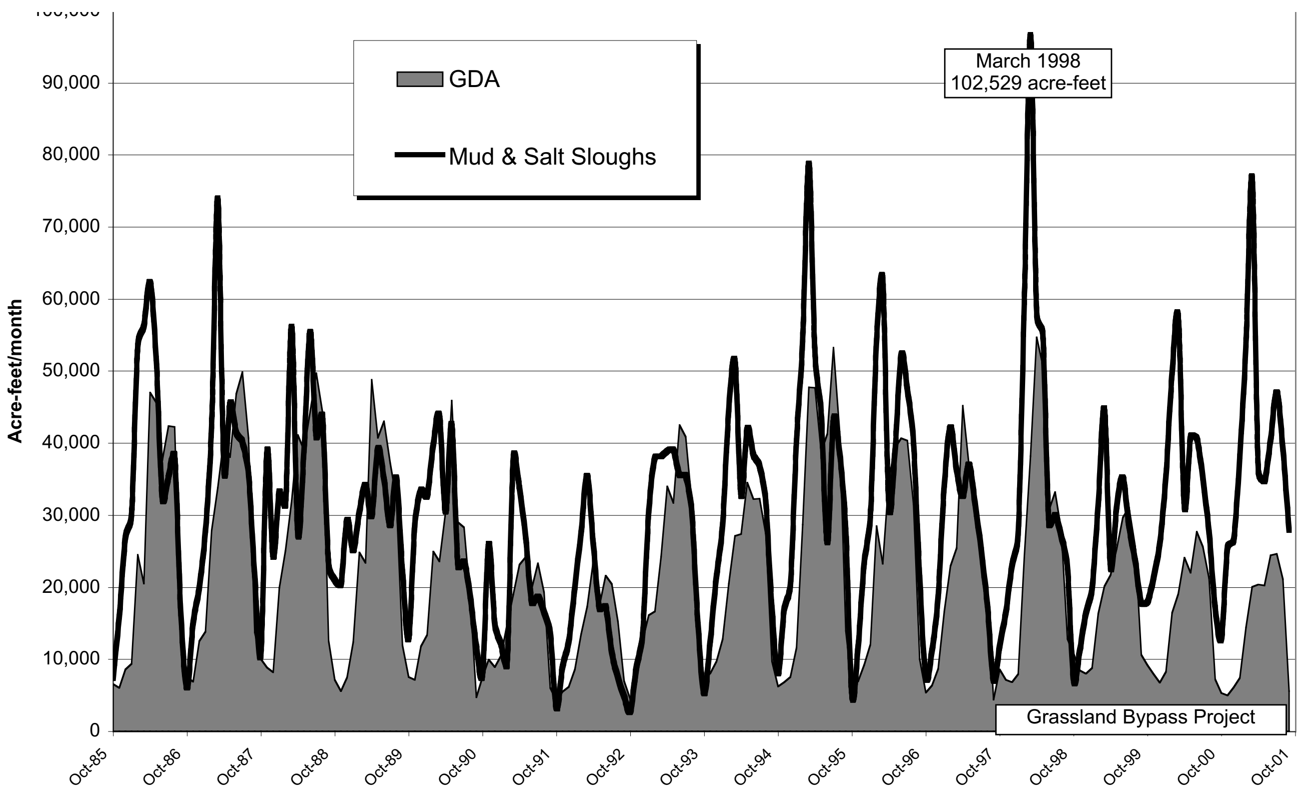
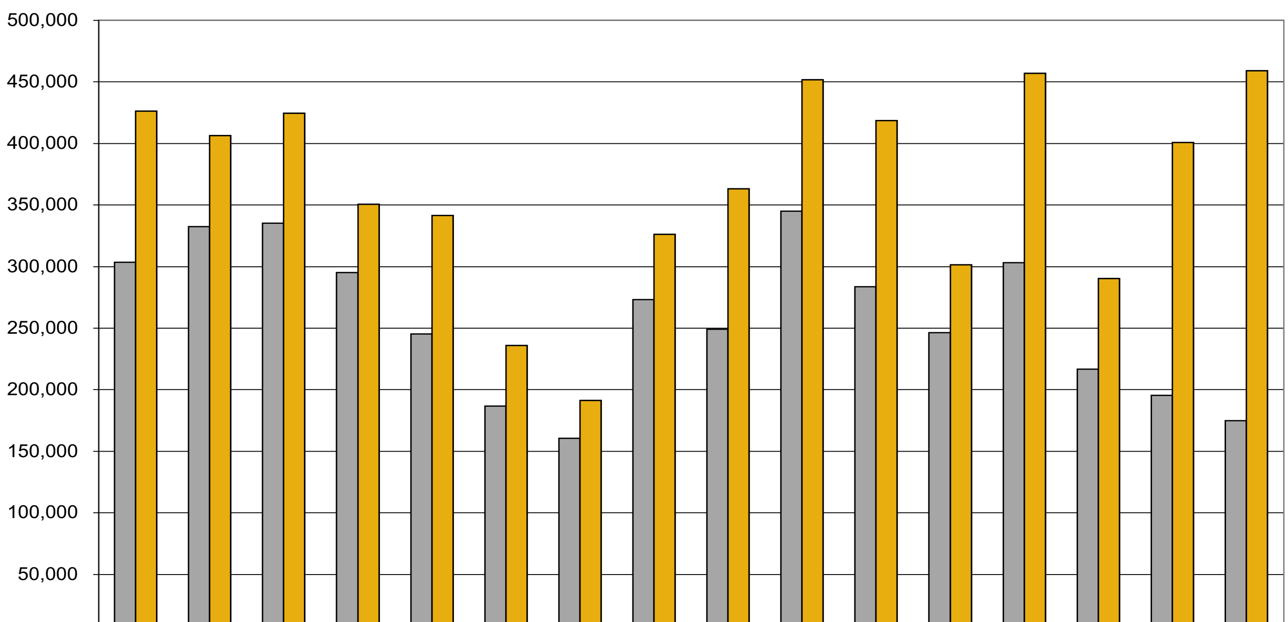


Figure 2. Annual Volumes of Water Needed to Dilute Drainage from the Grassland Drainage Area and the Regional Watershed to Meet Vernalis Standards (WY 1986 - 2001)



	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
GDA	303,361	332,189	335,151	294,834	245,167	186,454	160,419	272,851	249,057	344,983	283,339	246,094	302,996	216,577	195,422	174,543
Regional	426,147	406,134	424,453	350,406	341,299	235,849	191,068	325,964	363,094	451,505	418,393	301,219	456,678	290,092	400,730	458,769

Table 4a. Annual Volumes of Dilution Water Needed to Meet Vernalis Standards

Water Year (1)		Water Needed to Dilute GDA Discharge to Meet Vernalis Standard (3)	Water Needed to Dilute Regional Discharge to Meet Vernalis Standard (4)	GDA as percent of Region
		acre-feet	acre-feet	
WY 1986		303,361	426,147	71%
WY 1987		332,189	406,134	82%
WY 1988		335,151	424,453	79%
WY 1989		294,834	350,406	84%
WY 1990		245,167	341,299	72%
WY 1991		186,454	235,849	79%
WY 1992		160,419	191,068	84%
WY 1993		272,851	325,964	84%
WY 1994		249,057	363,094	69%
WY 1995		344,983	451,505	76%
WY 1996		283,339	418,393	68%
WY 1997	GBP	246,094	301,219	82%
WY 1998	GBP	302,996	456,678	66%
WY 1999	GBP	216,577	290,092	75%
WY 2000	GBP	195,422	400,730	49%
WY 2001	GBP	174,543	458,769	38%

Table 4b. Comparison of Dilution Requirements

		Water Needed to Dilute GDA Discharge to Meet Vernalis Standard (3)	WY 2001 difference	Water Needed to Dilute Regional Discharge to Meet Vernalis Standard (4)	WY 2001 difference
		acre-feet		acre-feet	
Average, all years	1986 - 2001	258,965	-33%	365,112	26%
Prior years average	1986 - 2000	264,593	-34%	358,869	28%
Before GBP average	1986 - 1996	273,437	-36%	357,665	28%
GBP average	1997 - 2001	227,126	-23%	381,498	20%
Drought years	(5)	214,749	-19%	319,341	44%
Wet years	(6)	290,643	-40%	394,110	16%

Notes:

Data compiled by Nigel Quinn, LBNL, from CVRWQCB and USGS reports.

(1) Water Year - October 1 - September 30

(2) Percent of Contract Delivery of CVP water to Delta Division and San Luis Unit

(3) Grassland Drainage Area

(4) Mud and Salt Sloughs

(5) Drought Years with 50% or less CVP delivery: WY 1990 - 1994, 2001

(6) Wet Years with more than 50 percent CVP delivery: WY 1986 - 1989, 1995 - 2000